fed into exchange towers and then to an ammonia converter. Inside the towers the gas flows from the bottom to the top while the liquid ammonia flows from the top to the bottom. The deuterium is stripped from the hydrogen in the systhesis gas and concentrated in the ammonia. The ammonia then flows into an ammonia cracker at the bottom of the tower while the gas flows into an ammonia converter at the top. Further enrichment takes place in subsequent stages and reactor-grade heavy water is produced through final distillation. The synthesis gas feed can be provided by an ammonia plant that can be constructed in association with a heavy water ammonia-hydrogen exchange plant. The ammonia-hydrogen exchange process can also use ordinary water as a feed source of deuterium.

C.1. Much of the key equipment for heavy water production plants using either the water-hydrogen sulphide exchange process (GS process) or the ammonia-hydrogen exchange process are common to several segments of the chemical and petroleum industries; particularly in small plants using the GS process. However, few items are available ''off-the-shelf.'' Both processes require the handling of large quantities of flammable, corrosive and toxic fluids at elevated pressures. Thus, in establishing the design and operating standards for plants and equipment using these processes, careful attention to materials selection and specifications is required to ensure long service life with high safety and reliability factors. The choice is primarily a function of economics and need. Most equipment, therefore, is prepared to customer requirements.

In both processes, equipment which individually is not especially designed or prepared for heavy water production can be assembled into especially designed or prepared systems for producing heavy water. Examples of such systems are the catalyst production system used in the ammonia-hydrogen exchange process and the water distillation systems used for the final concentration of heavy water to reactor-grade in either process.

C.2. Equipment especially designed or prepared for the production of heavy water utilizing either the water-hydrogen sulphide exchange process or the ammonia-hydrogen exchange process:

(i) Water-hydrogen Sulphide Exchange Towers

Exchange towers fabricated from carbon steel (such as ASTM A516) with diameters of 6 m (20 ft) to 9 m (30 ft), capable of operating at pressures greater than or equal to 2 MPa (300 psi) and with a corrosion allowance of 6mm or greater.

(ii) Blowers and Compressors

Single stage, low head (*i.e.*, 0.2 MPa or 30 psi) centrifugal blowers or compressors for hydrogen-sulphide gas circulation (*i.e.*, gas containing more than 70 percent H_2 S). The blowers or compressors have a throughput capacity greater than or equal to 56 m^3/second (120,000 SCFM) while operating at pressures greater than or equal to 1.8 MPa (260 psi) suction and have seals designed for wet H_2 S service.

(iii) Ammonia-Hydrogen Exchange Towers

Ammonia-hydrogen exchange towers greater than or equal to 35 m (114.3 ft) in height with diameters of 1.5 m (4.9 ft) to 2.5 m (8.2 ft) capable of operating at pressures greater than 15 MPa (2225 psi). The towers have at least one flanged, axial opening of the same diameter as the cylindrical part through which the tower internals can be inserted or withdrawn.

(iv) Tower Internals and Stage Pumps Used in the Ammonia-hydrogen Exchange Process.

Tower internals include especially designed stage contactors which promote intimate gas/liquid contact. Stage pumps include especially designed submersible pumps for circulation of liquid ammonia within a contacting stage internal to the stage towers.

(v) Ammonia Crackers Utilizing the Ammonia-hydrogen Exchange Process.

Ammonia crackers with operating pressures greater than or equal to 3 MPa (450 psi).

(vi) Infrared Absorption Analyzers

Infrared absorption analyzers capable of ''on-line'' hydrogen/deuterium ratio analysis where deuterium concentrations are equal to or greater than 90 percent.

(vii) Catalytic Burners Used in the Ammonia-hydrogen Exchange Process.

Catalytic burners for the conversion of enriched deuterium gas into heavy water.

(viii) Complete Heavy Water Upgrade Systems or Columns.

Complete heavy water upgrade systems or columns especially designed or prepared for the upgrade of heavy water to reactor-grade deuterium concentration. These systems, which usually employ water distillation to separate heavy water from light water, are especially designed or prepared to produce reactor-grade heavy water (*i.e.*, typically 99.75% deuterium oxide) from heavy water feedstock of lesser concentration.

[58 FR 13005, Mar. 9, 1993. Redesignated at 61 FR 35603, July 8, 1996; 65 FR 70292, Nov. 22, 2000]

APPENDIX L TO PART 110—ILLUSTRATIVE LIST OF BYPRODUCT MATERIALS UNDER NRC EXPORT/IMPORT LICENSING AUTHORITY [a]

Actinium 225 (Ac 225)
Actinium 227 (Ac 227)
Actinium 228 (Ac 228)
Americium 241 (Am 241)
Americium 242m (Am 242m)
Americium 242 (Am 242)
Americium 243 (Am 243)
Antimony 124 (Sb 124)
Antimony 125 (Sb 125)
Antimony 126 (Sb 126)
Arsenic 73 (As 73)
Arsenic 74 (As 74)
Arsenic 76 (As 76)
Arsenic 77 (As 77)
Barium 131 (Ba 131)
Barium 133 (Ba 133)
Barium 140 (Ba 140)
Bismuth 207 (Bi 207)
Bismuth 210 (Bi 210)
Bromine 82 (Br 82)
Cadmium 109 (Cd 109)
Cadmium 113 (Cd 113)
Cadmium 115m (Cd 115m)
Cadmium 115 (Cd 115)
Calcium 45 (Ca 45)
Calcium 47 (Ca 47)
Californium 248 (Cf 248)
Californium 249 (Cf 249)
Californium 250 (Cf 250)
Californium 251 (Cf 251)
Californium 252 (Cf 252)
Californium 253 (Cf 253)
Californium 254 (Cf 254)
Carbon 11 (C 11)
Carbon 14 (C 14)
Cerium 141 (Ce 141)
Cerium 143 (Ce 143)
Cerium 144 (Ce 144)
Cesium 129 (Cs 129)
Cesium 131 (Cs 131)
Cesium 134m (Cs 134m)
Cesium 134 (Cs 134)
Cesium 135 (Cs 135)
Cesium 136 (Cs 136)
Cesium 137 (Cs 137)
Chlorine 36 (Cl 36)
Chlorine 38 (Cl 38)
Chromium 51 (Cr 51)
Cobalt 57 (Co 57)
Cobalt 58m (Co 58m)
Cobalt 58 (Co 58)
Cobalt 60 (Co 60)
Copper 64 (Cu 64)
Curium 240 (Cm 240)
Curium 241 (Cm 241)
Curium 242 (Cm 242)
Curium 243 (Cm 243)
Curium 244 (Cm 244)
Curium 245 (Cm 245)
Curium 247 (Cm 247)
Dysprosium 165 (Dy 165)
Dysprosium 166 (Dy 166)
Einsteinium 252 (Es 252)
Einsteinium 253 (Es 253)
Einsteinium 254 (Es 254)
Einsteinium 255 (Es 255)
Erbium 169 (Er 169)
Erbium 171 (Er 171)
Europium 152 (Eu 152)
Europium 152 9.2 h (Eu 152 9.2 h)
Europium 152 13 yr (Eu 152 13 yr)
Europium 154 (Eu 154)
Europium 155 (Eu 155)
Fermium 257 (Fm 257)
Fluorine 18 (F 18)
Gadolinium 148 (Gd 148)
Gadolinium 153 (Gd 153)
Gadolinium 159 (Gd 159)
Gallium 67 (Ga 67)
Gallium 72 (Ga 72)
Germanium 68 (Ge 68)
Germanium 71 (Ge 71)
Gold 195 (Au 195)
Gold 198 (Au 198)
Gold 199 (Au 199)
Hafnium 172 (Hf 172)
Hafnium 181 (Hf 181)
Holmium 166m (Ho 166m)
Holmium 166 (Ho 166)
Hydrogen 3 (H 3)
Indium 111 (In 111)
Indium 113m (In 113m)
Indium 114m (In 114m)
Indium 115m (In 115m)
Indium 115 (In 115)
Iodine 123 (I 123)
Iodine 125 (I 125)
Iodine 126 (I 126)
Iodine 129 (I 129)
Iodine 131 (I 131)
Iodine 132 (I 132)
Iodine 133 (I 133)
Iodine 134 (I 134)
Iodine 135 (I 135)
Iridium 192 (Ir 192)
Iridium 194 (Ir 194)
Iron 52 (Fe 52)
Iron 55 (Fe 55)
Iron 59 (Fe 59)
Krypton 85 (Kr 85)
Krypton 87 (Kr 87)
Lanthanum 140 (La 140)
Lead 210 (Pb 210)
Lutetium 177 (Lu 177)
Manganese 52 (Mn 52)
Manganese 54 (Mn 54)
Manganese 56 (Mn 56)
Mendelevium 258 (Md 258)
Mercury 197m (Hg 197m)
Mercury 197 (Hg 197)
Mercury 203 (Hg 203)
Molybdenum 99 (Mo 99)
Neodymium 147 (Nd 147)
Neodymium 149 (Nd 149)
Neptunium 235 (Np 235)
Neptunium 237 (Np 237)
Nickel 59 (Ni 59)
Nickel 63 (Ni 63)
Nickel 65 (Ni 65)
Niobium 93m (Nb 93m)
Niobium 94 (Nb 94)
Niobium 95 (Nb 95)
Niobium 97 (Nb 97)
Nitrogen 13 (N 13)
Osmium 185 (Os 185)
Osmium 191m (Os 191m)
Osmium 191 (Os 191)
Osmium 193 (Os 193)
Oxygen 15 (O 15)
Palladium 103 (Pd 103)
Palladium 109 (Pd 109)
Phosphorus 32 (P 32)
Phosphorus 33 (P 33)
Platinum 191 (Pt 191)
Platinum 193m (Pt 193m)
Platinum 193 (Pt 193)
Platinum 197m (Pt 197m)
Platinum 197 (Pt 197)
Polonium 208 (Po 208)
Polonium 209 (Po 209)
Polonium 210 (Po 210)
Potassium 42 (K 42)
Potassium 43 (K 43)
Praseodymium 142 (Pr 142)
Praseodymium 143 (Pr 143)
Promethium 145 (Pm 145)
Promethium 147 (Pm 147)
Promethium 149 (Pm 149)
Radium 223 (Ra 223)
Radium 226 (Ra 226)[b]
Rhenium 186 (Re 186)
Rhenium 188 (Re 188)
Rhodium 103m (Rh 103m)
Rhodium 105 (Rh 105)
Rubidium 81 (Rb 81)
Rubidium 86 (Rb 86)
Rubidium 87 (Rb 87)
Ruthenium 97 (Ru 97)
Ruthenium 103 (Ru 103)
Ruthenium 105 (Ru 105)
Ruthenium 106 (Ru 106)
Samarium 151 (Sm 151)
Samarium 153 (Sm 153)
Scandium 46 (Sc 46)
Scandium 47 (Sc 47)
Scandium 48 (Sc 48)
Selenium 75 (Se 75)
Silicon 31 (Si 31)
Silver 105 (Ag 105)
Silver 110m (Ag 110m)
Silver 111 (Ag 111)
Sodium 22 (Na 22)
Sodium 24 (Na 24)
Strontium 85 (Sr 85)
Strontium 89 (Sr 89)
Strontium 90 (Sr 90)
Strontium 91 (Sr 91)
Strontium 92 (Sr 92)
Sulphur 35 (S 35)
Tantalum 182 (Ta 182)
Technetium 96 (Tc 96)
Technetium 97m (Tc 97m)
Technetium 97 (Tc 97)
Technetium 99m (Tc 99m)
Technetium 99 (Tc 99)

[a] Any accelerator-produced material produced, extracted, or converted for use for a commercial, medical, or research activity.

[b] Discrete sources of radium-226 (Ra-226).

Tellurium 125m (Te 125m)
Tellurium 127m (Te 127m)
Tellurium 127 (Te 127)
Tellurium 129m (Te 129m)
Tellurium 129 (Te 129)
Tellurium 131m (Te 131m)
Tellurium 132 (Te 132)
Terbium 160 (Tb 160)
Thallium 200 (Tl 200)
Thallium 201 (Tl 201)
Thallium 202 (Tl 202)
Thallium 204 (Tl 204)
Thulium 170 (Tm 170)
Thulium 171 (Tm 171)
Tin 113 (Sn 113)
Tin 123 (Sn 123)
Tin 125 (Sn 125)
Tin 126 (Sn 126)
Titanium 44 (Ti 44)
Tritium (H3)
Tungsten 181 (W 181)
Tungsten 185 (W 185)
Tungsten 187 (W 187)
Vanadium 48 (V 48)
Xenon 131m (Xe 131m)
Xenon 133 (Xe 133)
Xenon 135 (Xe 135)
Ytterbium 175 (Yb 175)
Yttrium 87 (Y 87)
Yttrium 88 (Y 88)
Yttrium 90 (Y 90)
Yttrium 91 (Y 91)
Yttrium 92 (Y 92)
Yttrium 93 (Y 93)
Zinc 65 (Zn 65)
Zinc 69m (Zn 69m)
Zinc 69 (Zn 69)
Zirconium 93 (Zr 93)
Zirconium 95 (Zr 95)
Zirconium 97 (Zr 97)

[58 FR 13005, Mar. 9, 1993, as amended at 59 FR 48998, Sept. 26, 1994. Redesignated and amended at 61 FR 35603, 35607, July 8, 1996; 65 FR 70292, Nov. 22, 2000; 71 FR 20339, Apr. 20, 2006; 75 FR 44093, July 28, 2010]

APPENDIX M TO PART 110—CATEGORIZATION OF NUCLEAR MATERIAL [d]

[From IAEA INFCIRC/225, Rev. 1]

Material	Form	Category		
		I	II	III [e]
1. Plutonium [a]	Unirradiated [b]	2 kg or more	Less than 2 kg but more than 500 g.	500 g or less.
2. Uranium-235 [c]	Unirradiated: [b].			
	Uranium enriched to 20 pct U^{235} or more.	5 kg or more	Less than 5 kg but more than 1 kg.	1 kg or less.
	Uranium enriched to 10 pct U^{235} but less than 20 pct.		10 kg or more	Less than 10 kg.
	Uranium enriched above natural, but less than 10 pct U^{235}.			10 kg or more.
3. Uranium-233	Unirradiated [b]	2 kg or more	Less than 2 kg but more than 500 g.	500 g or less.

[a] All plutonium except that with isotopic concentration exceeding 80 pct in plutonium-238.
[b] Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 100 rd/h at 1 m unshielded.
[c] Natural uranium, depleted uranium, thorium and quantities of uranium enriched to less than 10% not falling into Category III should be protected in accordance with prudent management practice.
[d] Irradiated fuel should be protected as category I, II, or III nuclear material depending on the category of the fresh fuel. However, fuel which by virtue of its original fissile material content is included as category I or II before irradiation should only be reduced one category level, while the radiation level from the fuel exceeds 100 rd/h at 1 m unshielded.
[e] Physical security determinations will not be required for 15 g or less of plutonium, uranium-233 or high-enriched uranium, or for 1 kg or less of uranium with an enrichment between 10 and 20 pct in uranium-235.

(Sec. 161, as amended, Pub. L. 83-703, 68 Stat. 948 (42 U.S.C. 2201); sec. 201, as amended, Pub. L. 93-438, 88 Stat. 1243 (42 U.S.C. 5841))

[43 FR 21641, May 19, 1978. Redesignated and amended at 49 FR 47204, Dec. 3, 1984. Further redesignated at 55 FR 30450, July 26, 1990; 58 FR 13005, Mar. 9, 1993; 61 FR 35603, July 8, 1996]

APPENDIX N TO PART 110—ILLUSTRATIVE LIST OF LITHIUM ISOTOPE SEPARATION FACILITIES, PLANTS AND EQUIPMENT UNDER NRC'S EXPORT LICENSING AUTHORITY

a. Facilities or plants for the separation of lithium isotopes.

b. Equipment for the separation of lithium isotopes, such as:

(1) Packed liquid-liquid exchange columns especially designed for lithium amalgams;

(2) Mercury and/or lithium amalgam pumps;

(3) Lithium amalgam electrolysis cells;

(4) Evaporators for concentrated lithium hydroxide solution.

[65 FR 70292, Nov. 22, 2000]

APPENDIX O TO PART 110—ILLUSTRATIVE LIST OF FUEL ELEMENT FABRICATION PLANT EQUIPMENT AND COMPONENTS UNDER NRC'S EXPORT LICENSING AUTHORITY

NOTE: Nuclear fuel elements are manufactured from source or special nuclear material. For oxide fuels, the most common type of fuel equipment for pressing pellets, sintering, grinding and grading will be present. Mixed oxide fuels are handled in glove boxes (or equivalent containment) until they are